PCA-RECT: An Energy-efficient Object Detection Approach for Event Cameras

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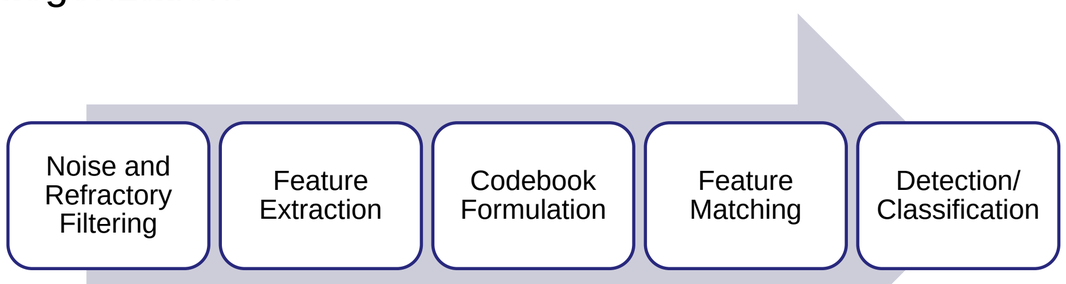
Introduction

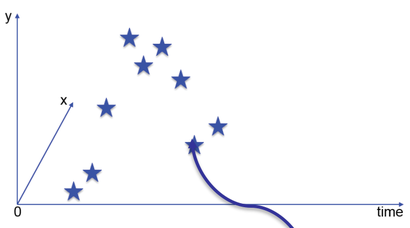
PCA-RECT is an energy-efficient feature representation for silicon retinas that can be used for object detection and categorization.



Motivation & Objective

Asynchronous Time-based Image Sensor (ATIS)

Dynamic Vision Sensor (DVS)



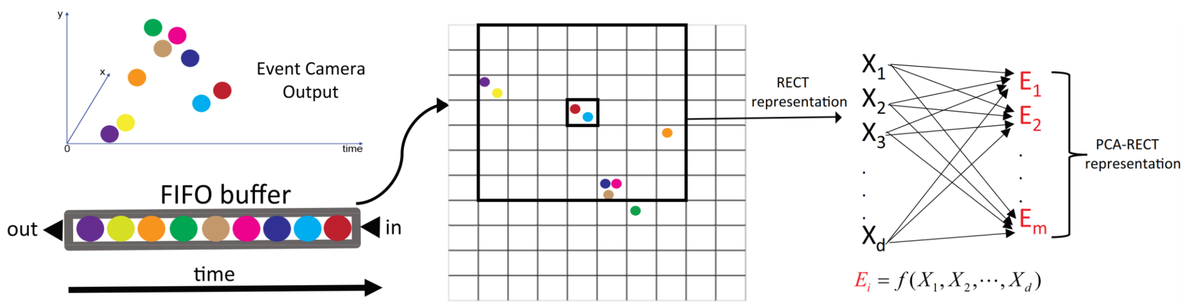
Spatial location (x,y)
Timestamp (in **µs**)
Polarity (1 or 0)

Event cameras do not suffer from motion blur and have high temporal resolution and a wide dynamic range

Objective: Develop an event-based, energy-efficient object detection approach to recognize objects present in natural settings on an FPGA.

Concept

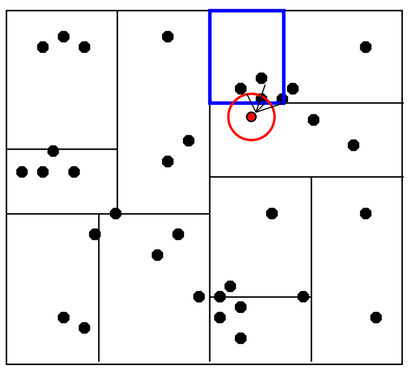
To obtain a robust feature representation, events are subsampled with a rectangular grid and projected onto a lower dimensional subspace.

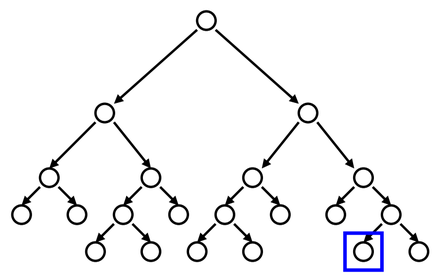


RECT stands for Rectangular Event Context Transform
PCA stands for the standard Principal Component Analysis

FPGA Implementation

The FPGA implementation is designed by keeping hardware resource limitations. For example, a virtual projection instead of PCA using a *k*-d tree is used as described below.





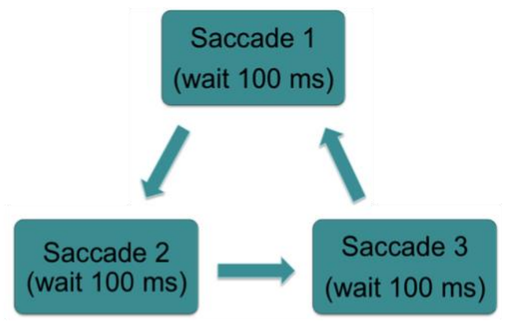
Two critical observations

1) Leaf node is a good approximation to the NN: pure logic-driven feature matching!
2) Only a fraction of the dimensions are used by the *k*-d tree. Thus, automatically discard dimensions during feature matching. This is termed as virtual PCA-RECT.

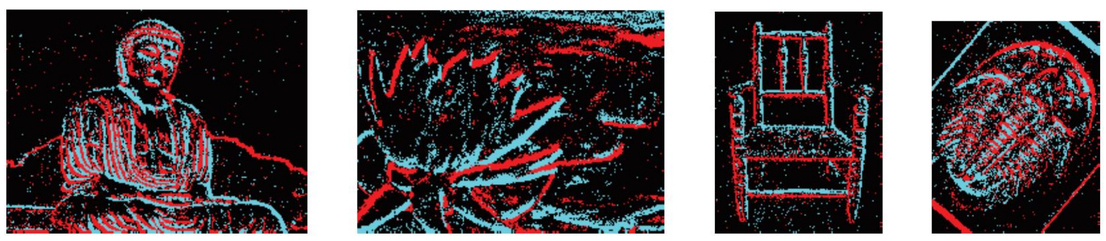
Object Classification and Detection

Offline test on N-MNIST and N-Caltech101

- A spiking neuromorphic version of the original MNIST and Caltech101 datasets.
- Obtained by moving an event-based camera in a loop while viewing images.



Images obtained by compressing events into a single frame



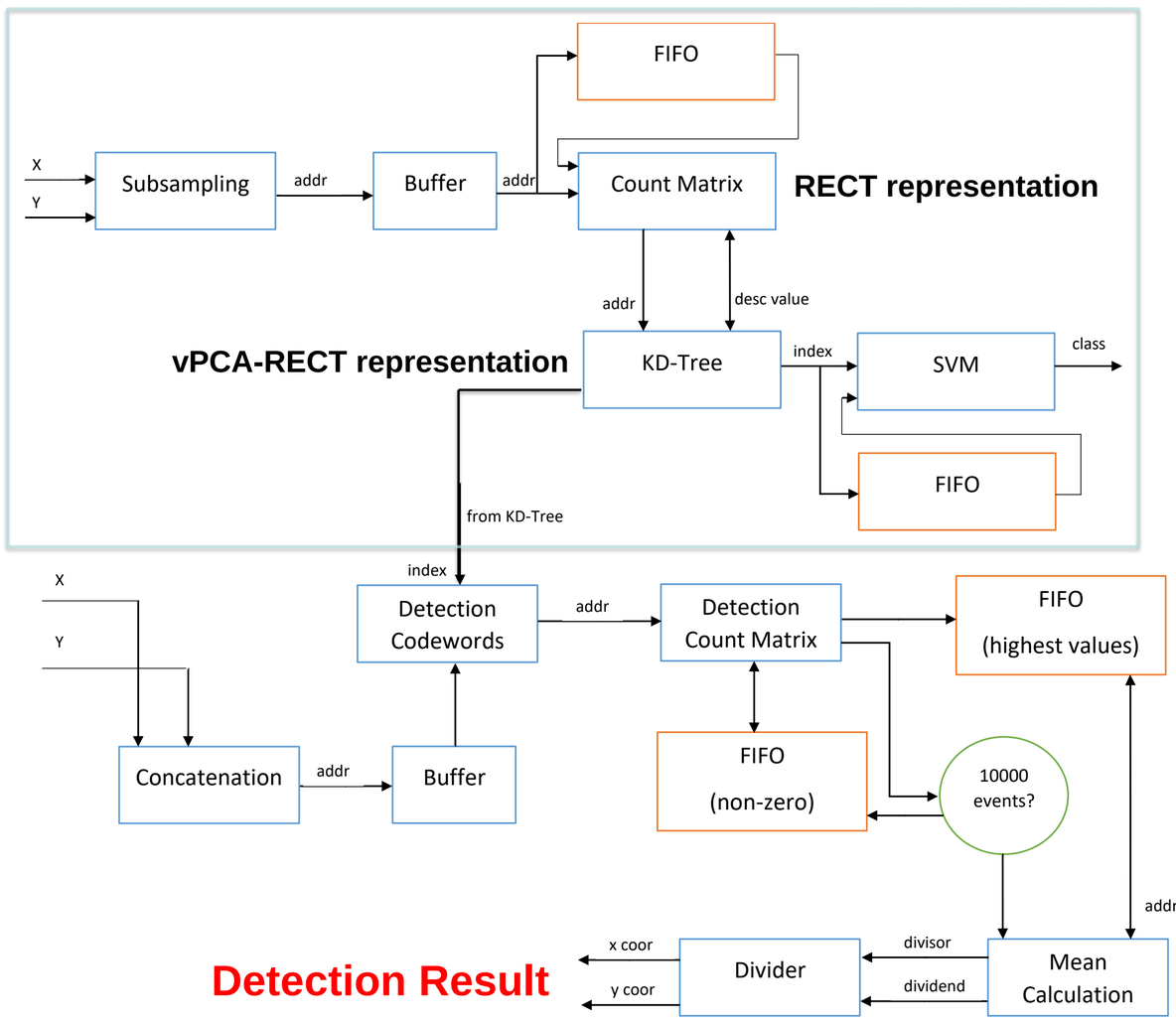
N-Caltech101 samples

Object Classification Results

	N-MNIST	N-Caltech101
H-First	71.20	5.40
HOTS	80.80	21.0
Gabor-SNN	83.70	19.60
HATS	**99.10**	64.20
vPCA-RECT (this work)	98.72	70.25
PCA-RECT (this work)	98.95	**72.30**
Phased LSTM	97.30	-
Deep SNN	98.70	-

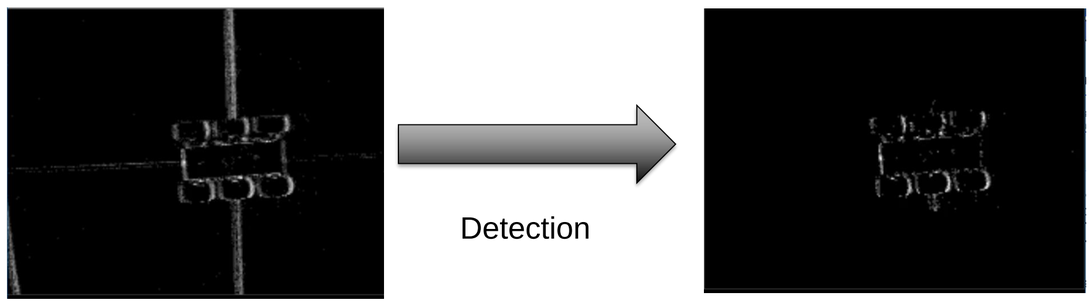
*HATS is an unpublished arXiV work from Ryad Benosman's group

FPGA Pipeline



Detection Result

Demo Scenario



Key References

1. Ramesh, B., Yang, H., Orchard, G., Anh Le Thi, N. and Xiang, C. (2018). DART: Distribution Aware Retinal Transform for Event-based Cameras (arXiV preprint).
2. Ramesh, Bharath, et al. "Long-term object tracking with a moving event camera." BMVC 2018

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